Effect of N-fixation on nitrous oxide emissions in mature caragana shelterbelts

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Introduction

Caragana arborescens (caragana) is a woody legume in the family Fabaceae. It is native to north-eastern Europe and central Asia and was introduced to North America in 1752. In Saskatchewan, there exists a long history of the cultivation of caragana for mitigating wind erosion. Its tolerance to cold and drought, height of 4-6 m, long lifespan and ability to fix nitrogen make it a good choice for shelterbelts. Nitrogen-fixation in caragana is around 335 µg N g soil^{-1} h^{-1} and about 80% of total N in caragana is derived from N-fixation (Moukoumi et al., 2013). Nitrogen inputs derived from N-fixation can exceed plant N requirements which may lead to N_2O emissions. Cultivation of shelterbelt trees has been promoted as having the potentials for mitigating atmospheric CO_2; however, the impact of N-fixation in caragana shelterbelts on N_2O emissions is unknown. The objective of the study was to investigate the contribution of caragana shelterbelt trees to soil N_2O emissions

Materials and Methods

A caragana shelterbelt was identified in each of the study sites (Fig 1). Nearby non N-fixing shelterbelts (conifers) were equally identified. The age of the shelterbelts range between 32 and 40 years. Four replicate chamber bases were installed in the middle of the shelterbelts and were used to monitor N_2O emissions over one year period. Gas samples from the chamber headspace were collected weekly and analyzed using a gas chromatograph (Bruker 450-GC). Four replicate soil samples were collected from each treatment and analyzed for N content, SOC, pH and texture

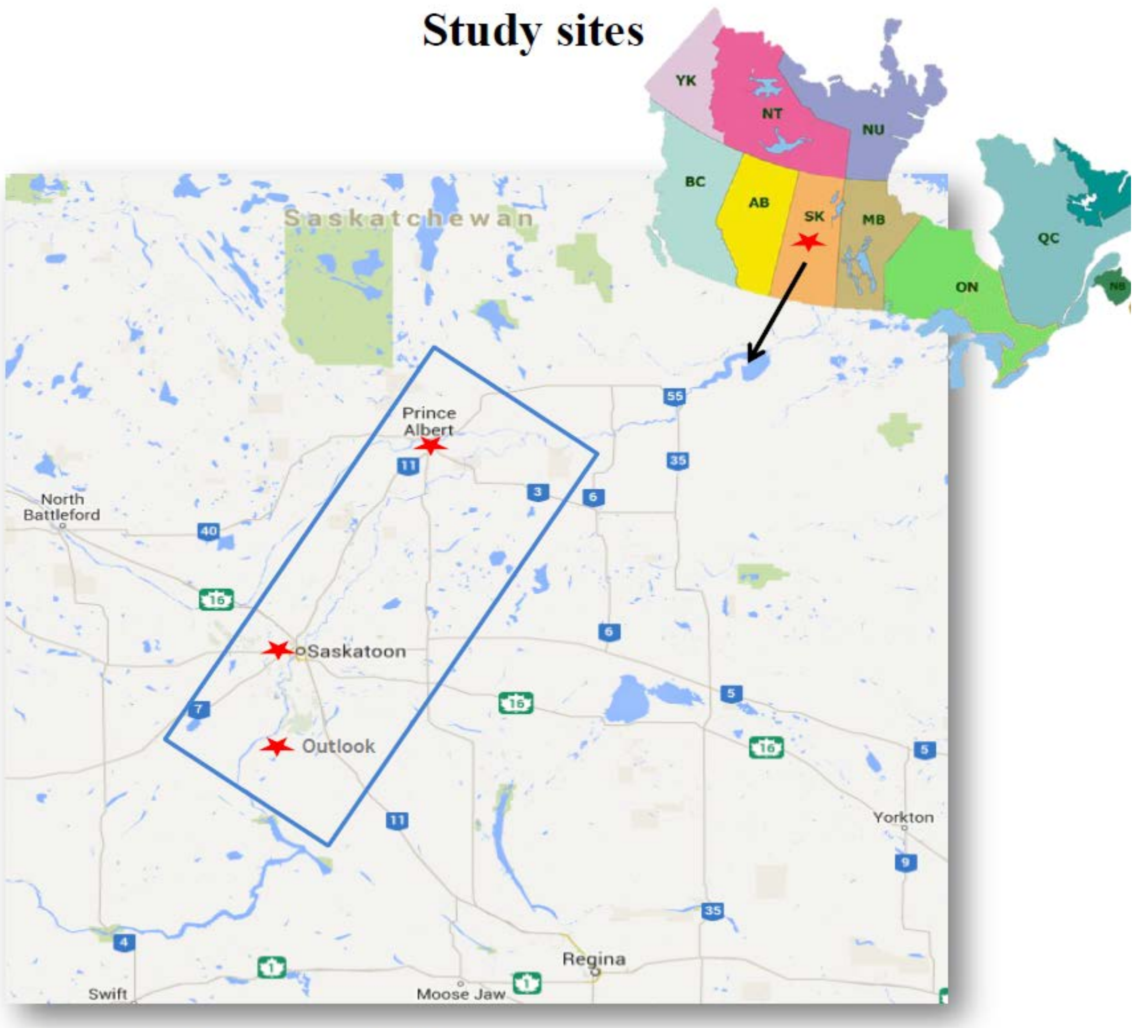

Figure 1. Map of study sites

Results and Discussion

In all sites, soil NO_3-N was greater in caragana shelterbelts (0.52 to 1.69 mg L^{-1}) than in their non N-fixing shelterbelt counterparts (0.04 to 0.88 mg L^{-1}); (Table 1). The increased NO_3-N in caragana shelterbelts may be attributable to accrual and microbial decomposition of N-rich plant residues, roots and old nodules. When soil moisture and temperature become conducive for microbial activities, increased NO_3-N could potentially result in gaseous N emission due to increased rate of biological nitrification and denitrification.

Table 1. Summary of soil properties from caragana and non N-fixing shelterbelt plots

Location	Treatment	Texture	Organic C (%)	Total N (%)	NH_4-N (mg L^{-1})	NO_3-N (mg L^{-1})	BD (g cm^{-3})	pH
Prince Albert	Caragana,	Sandy loam	3.68	0.32	0.35	0.52	1.29	5.47
	Larch, white spruce	Sandy loam	3.53	0.30	0.51	0.04	1.34	4.78
Saskatoon	Caragana	Clay	4.17	0.40	0.50	1.69	0.93	7.45
	mixed species	Clay	4.17	0.33	0.46	0.88	1.07	7.42
Outlook	Caragana	Sandy loam	1.74	0.15	0.28	0.57	1.13	6.24
	Scotchpine	Sandy loam	2.02	0.18	0.43	0.35	1.17	7.13

Greenhouse gas emissions

Seasonal cumulative N_2O emissions from caragana shelterbelt plots were greater (183 to 409 g N_2O-N ha^{-1} yr^{-1}) than the non N-fixing plots (22 to 121 g N_2O-N ha^{-1} yr^{-1}) (Fig 3). Maximum daily N_2O emissions occurred during early spring (April – May) and summer (July to August) (Fig 2). These findings are in agreement with Izaurralde et al. (2004) and may be attributed to the presence of residual mineral N under the elevated soil moisture conditions in the spring and favourable conditions for microbial activity during the summer in the Caragana.

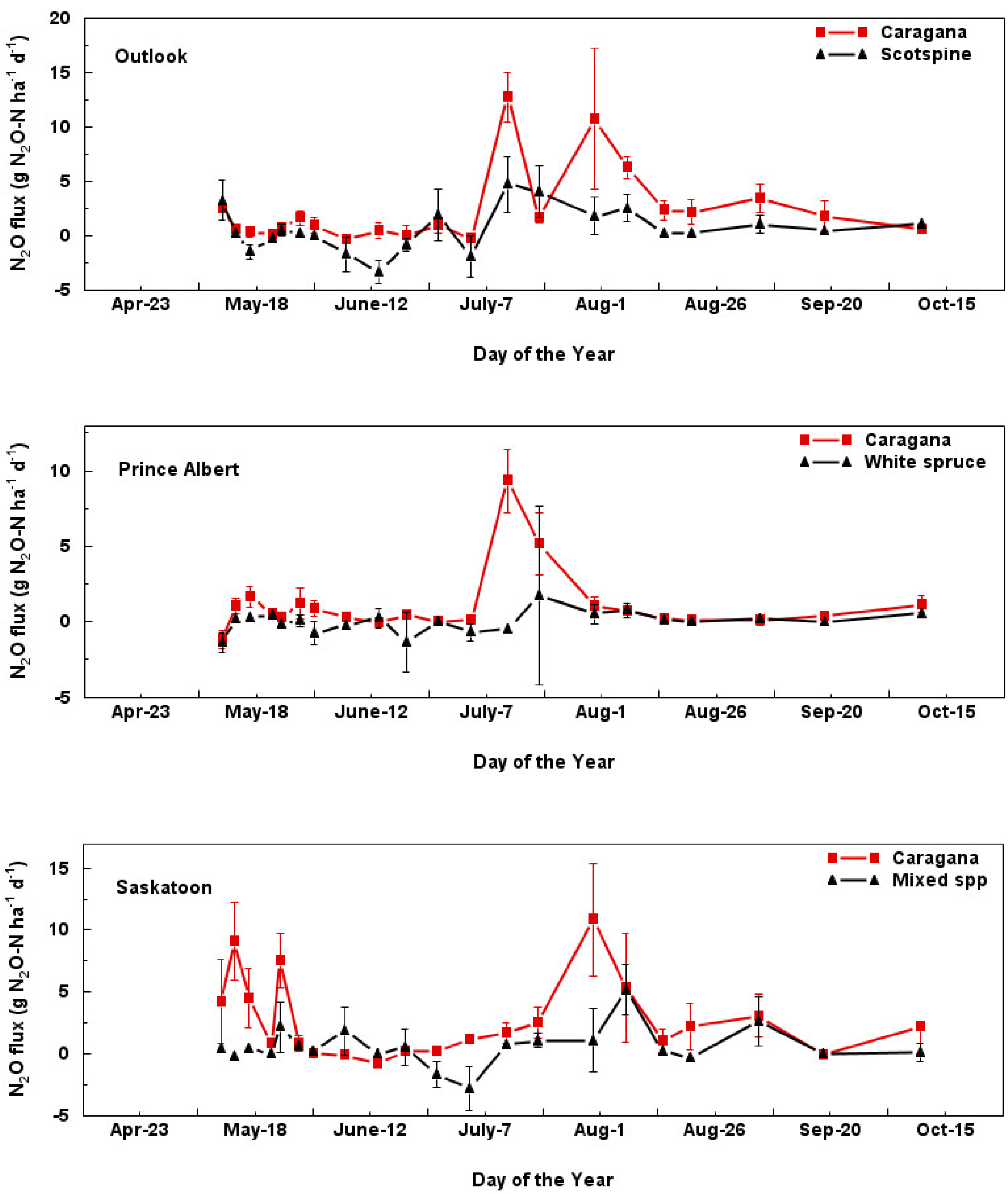

Figure 2. Average daily N_2O emissions from caragana and non N-fixing shelterbelt plots. Error bars represent standard deviation

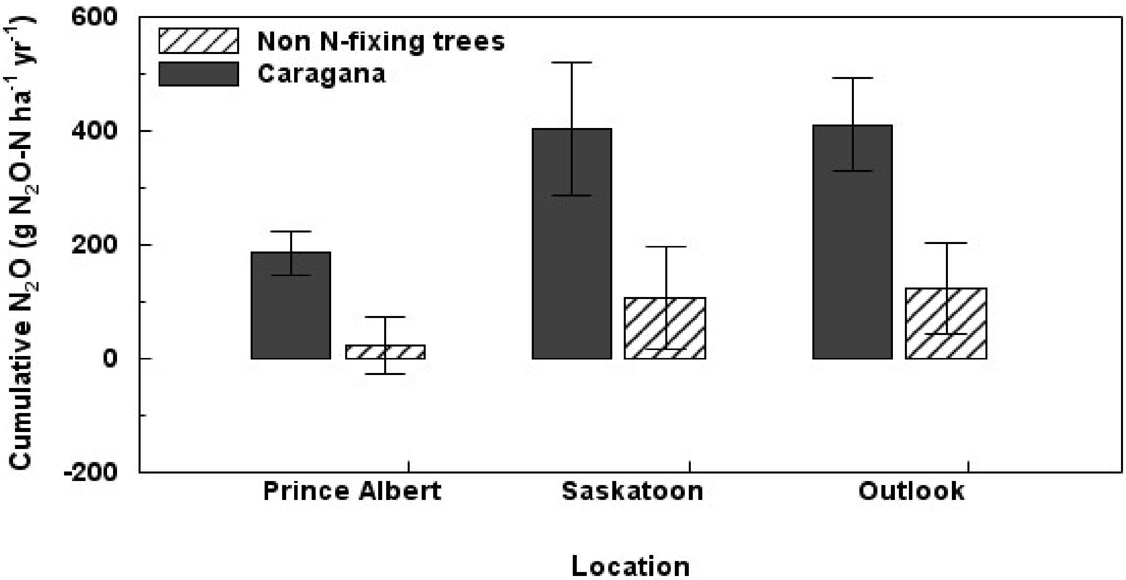

Figure 3. Average seasonal cumulative N_2O emissions from caragana and non N-fixing shelterbelt plots. Error bars represent standard deviation

Conclusion

The study show potential increase in NO_3-N and subsequent emissions of gaseous N in caragana shelterbelts in Saskatchewan. Although the use of N-fixing trees may be beneficial for carbon sequestration, they may be significant sources of atmospheric N_2O emissions. The success of agroforestry systems in mitigating climate change will depend on proper understanding of trade-offs between C sequestration and the emission of trace gases such as N_2O. Further research is needed on sustainable ways of designing shelterbelt tree species in such a way as to maximize the N-fixing feature of caragana trees while reducing potentials for N_2O emissions.

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